OIL AND GAS INDUSTRY STUDY

PART I: OIL AND GAS EXPLORATION AND DEVELOPMENT OVERVIEW

PART II: SUMMARY OF ENVIRONMENTAL LAWS AND REGULATIONS RELATING TO OIL AND GAS ACTIVITY

EQC STAFF REPORT
JANUARY 17, 1986

PART I: OIL AND GAS EXPLORATION AND DEVELOPMENT OVERVIEW

This overview of oil and natural gas exploration and development processes describes the sequence of events, equipment types, and environmental impacts commonly associated with the search for and commercial development of oil and gas reserves. Oil and gas production currently occurs in five areas of Montana (see the accompanying map entitled "Montana Oil and Gas Fields, Pipelines and Refineries): the Sweetgrass Arch-Bearpaw Uplift in Northern Montana, the Big Snowy Uplift in Central Montana, the Big Horn Basin in South Central Montana, the Powder River Basin in Southeastern Montana, and the Williston Basin in Northeast Montana. The most significant recent discoveries have occurred in the Williston Basin. A sixth area, the Overthrust Belt which runs roughly parallel to the east slopes of the Continental Divide throughout western Montana, is considered to have the potential to yield significant oil and gas reserves. Exploration in this area is continuing.

Oil and gas exploration and development normally progresses through the five phases shown in Table 1 if commercial quantities are discovered.

Preliminary Exploration

Oil and gas exploration and development has been occurring in Montana since the late 1800s commencing with initial drilling of several wells in the Red Lodge area in 1889 near locations where crude oil was naturally seeping from the ground. Theories linking the presence of oil and gas to certain types of underground geologic structures were first formulated in the mid-1800s, but exploration techniques based on stratigraphic factors were not applied in Montana until the 1920s, and use of geologic information was not a significant factor in exploration until the late 1940s, (Fanshowe, 1985). Figure 1 shows examples of typical geologic structures that may contain oil or gas.

Preliminary geological exploration involves ground and aerial surveys of a given area, along with aerial photo and geologic interpretation. Gravitational and magnetic surveys may be conducted to obtain subsurface geologic data. Some geophysical exploration can be done by air. Small trucks and jeeps with crews of several people can be used for ground surveys. Off-road travel is likely at this stage of subsurface data gathering (USDI 1981).

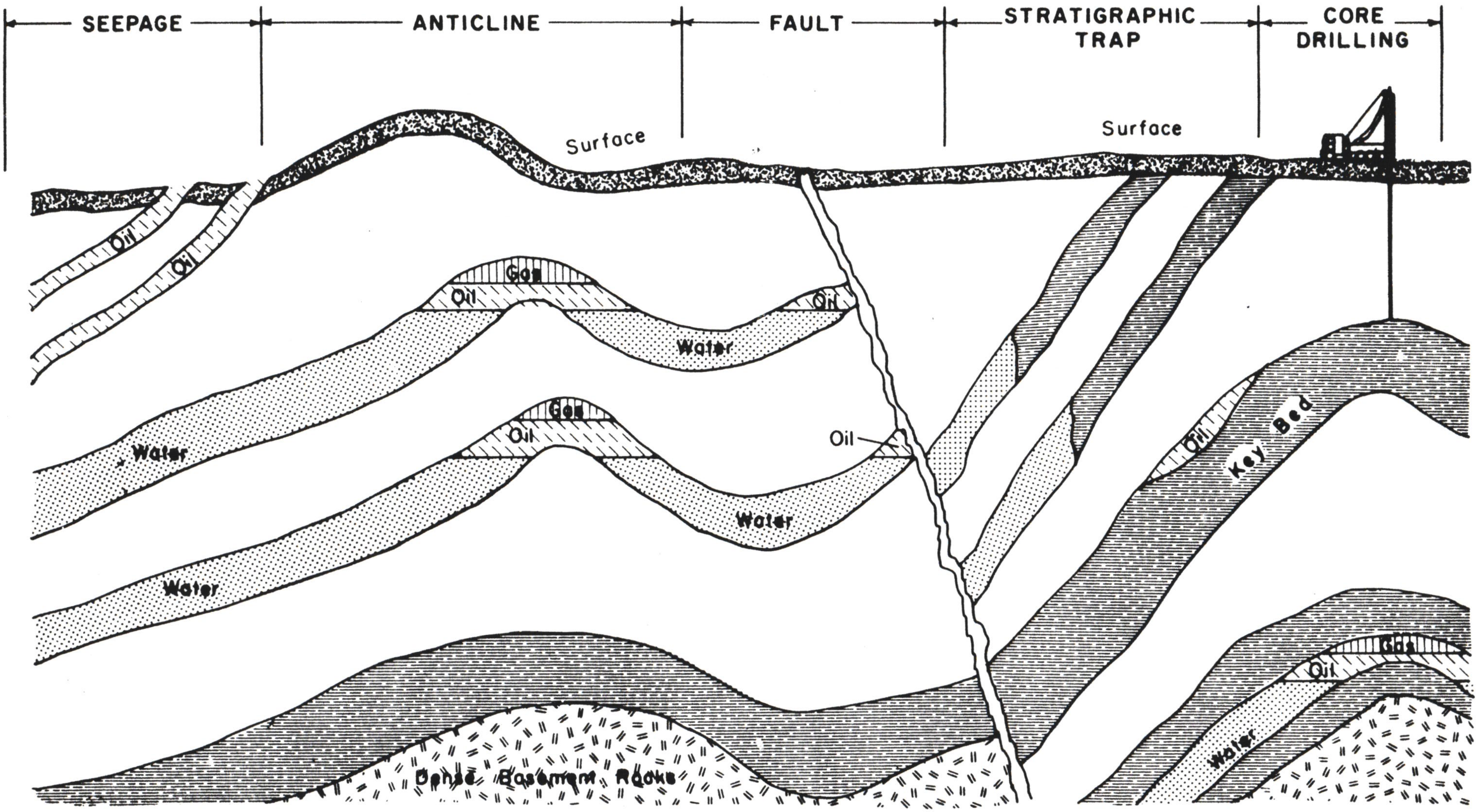
Seismic surveys are the most common of the geophysical exploration methods and seem to give the most reliable results (USDA 1979). Seismic surveys use artificially created shock waves to gather subsurface geologic information. Each formation reflects the shock wave back to a group of vibration detectors arrayed on the surface. Seismic testing is usually described by the methods and equipment used to generate the shock wave, which most commonly include thumpers, vibrators and explosives. The following descriptions are taken from Joslin (1981).

Table 1. Phases of oil and gas exploration, development and production.

- I. PRELIMINARY EXPLORATION
  - GEOPHYSICAL EXPLORATION
    - Gravity and Magnetics
    - Seismic
      - Thumper units
      - Vibroseis
      - Explosives
        - Subsurface
        - Surface
- II. EXPLORATORY DRILLING
  - STRATIGRAPHIC TESTS
  - WILDCAT WELLS
- III. DEVELOPMENT
  - FIELD DEVELOPMENT
  - TRANSPORTATION DEVELOPMENT
    - Roads
    - Pipelines
- IV. PRODUCTION
  - WELL FACILITIES
  - ON-SITE PROCESSING
    - a. Natural gas sweetening plants
    - b. Crude oil separators
  - DISPOSAL OF PRODUCED WATER
  - SECONDARY RECOVERY
  - TERTIARY RECOVERY
  - PIPELINES
- V. ABANDONMENT

FIGURE 1

TYPICAL OIL AND GAS TRAPS



Source: U.S. Department of the Interior, Plain Facts about Oil, 1963.

A thumper unit consists of a large truck (usually more than one is used at a time) from which a suspended 3-ton slab is repeatedly dropped to the ground from several feet high. Support vehicles for equipment and crew are necessary. Vibroseis typically involves three or four large trucks, each with a platform mounted underneath. The platforms are lowered and the trucks hydraulically raised above to provide the necessary weight. The entire unit vibrates when the motors on the trucks are electronically triggered from a recorder truck. Vibroseis surveys have the advantage of avoiding the disturbance that explosion methods impose on the land surface.

The subsurface explosion method may use a large truck mounted with equipment for drilling a 2-6 inch diameter hole 25-200 ft deep, into which 5-50 pounds of explosives are placed. When detonated, the explosion generates the shock wave. The Board of Oil and Gas Conservation regulates plugging and abandonment of the resulting "shot-holes". More recently developed techniques which produce acceptable data in some areas rely on surface detonation on the ground, on snow or on various types of platforms, thus avoiding most surface disturbance.

The seismic techniques require various trucks such as jug trucks, equipment trucks, recording trucks and personnel carriers. Shot hole drilling also may require water trucks and sources for water. A typical seismic operation may use 10-15 men and 5-7 trucks (USDI 1981). The seismic sensors and energy source are located along lines on a 1-2 mile grid. While existing roads are used if possible, a grid network of low standard temporary roads is needed for this operation. Alignment may be fairly critical, although spacing of the lines can sometimes be modified up to 1/4 mile on a one-mile grid without affecting test results (USDI 1980). In other cases there can be little modification of the road system to accommodate topography. Depending on topography, lines may require clearing of vegetation and loose rock to improve access for the trucks. Each mile of line cleared to a width of 8-14 feet represents disturbance of about an acre of land (USDI 1981). It should also be noted that seismic testing may be repeated several times before exploratory drilling starts.

When rugged terrain prevents use of ground vehicles, portable drills may be backpacked or flown by helicopter onto location. In such cases a series of 25-foot deep holes is drilled, loaded with explosives and detonated simultaneously.

Exploratory Drilling

If preliminary exploration reveals favorable results, stratigraphic testing involving exploratory drilling may take place. Exploratory drilling does not begin until a lease has been acquired from the minerals owner, and agreements reached with the land surface owner (if different than the minerals owner). Drilling is accomplished primarily by rotary rigs which are truck-mounted and fairly mobile. Roads and trails to test sites on level, solid ground are temporary and may involve a minimal amount of construction, while drilling in hilly and mountainous terrain usually involves more extensive disturbance.

The oil company must drill a "wildcat well" (i.e., a well drilled in unproven territory) in order to know if oil and gas is actually present and if its quality and quantity are adequate for profitable sale. The depth of wildcat wells and their rig size depend on the geology of an area. In the Williston Basin and Overthrust Belt areas, wells are commonly drilled to a depth of 10,000 feet or more. Drilling equipment could remain on this type of site for six months, while in other areas such as the northern part of Montana, shallower wells up to a few thousand feet are common and may be completed in a few days. Prior to drilling, a drill pad (well site) from 1-4 acres in size is cleared and leveled for the drill rig and its associated equipment and structures. From 50,000-100,000 gallons of water a day may be needed for mixing drilling mud, cleaning equipment, cooling engines, etc. A surface pipeline may be laid to a stream, pond, reservoir or a water well, or the water may be trucked to the site (USDI 1981). Once drilling is started, it continues 24 hours a day until completion.

Rock chips and cuttings are brought to the surface from the bottom of the drill hole by a flow of drilling mud or high-pressure air flow. Samples of the chips and cuttings are collected, bagged, and identified as to depth of their origin. The chips are then examined to determine the formation and structure from which they originated. This kind of information helps the geologist find a marker zone or formation to correlate the previously obtained geologic and geophysical information with actual structures.

Drilling is started by "spudding in" the well; that is, starting the hole. The basic concept of rotary drilling involves rotating a bit on the bottom of the hole with a drill pipe through which fluid is circulated to remove cuttings. The initial drilling usually proceeds rapidly and generally the string of surface casing is set before harder, deeper formations are encountered. The surface casing is a long length of steel pipe which is cemented into the hole primarily to protect surface water from mixing, loss or contamination. It is large enough to allow subsequent lengths of casing to be set as the well is deepened (see Figures 2 and 3). Also, surface casing provides for attachment of blowout preventers that are necessary in case a zone containing high-pressure gas, water, or oil is encountered. Without blowout protection, the contents of such zones could blow all the drilling mud out of the hole and flow out of control. Storage pits known as reserve pits are often located at or near the well site for storage and burial of the drilling mud.

During or at the completion of drilling, the well is electronically logged. Physical characteristics of the rock formations and associated fluids are measured with instruments lowered to the bottom of the well. Based on study of the well logs and drill stem test data, the geologist decides whether the well has encountered sufficient quantities of oil or

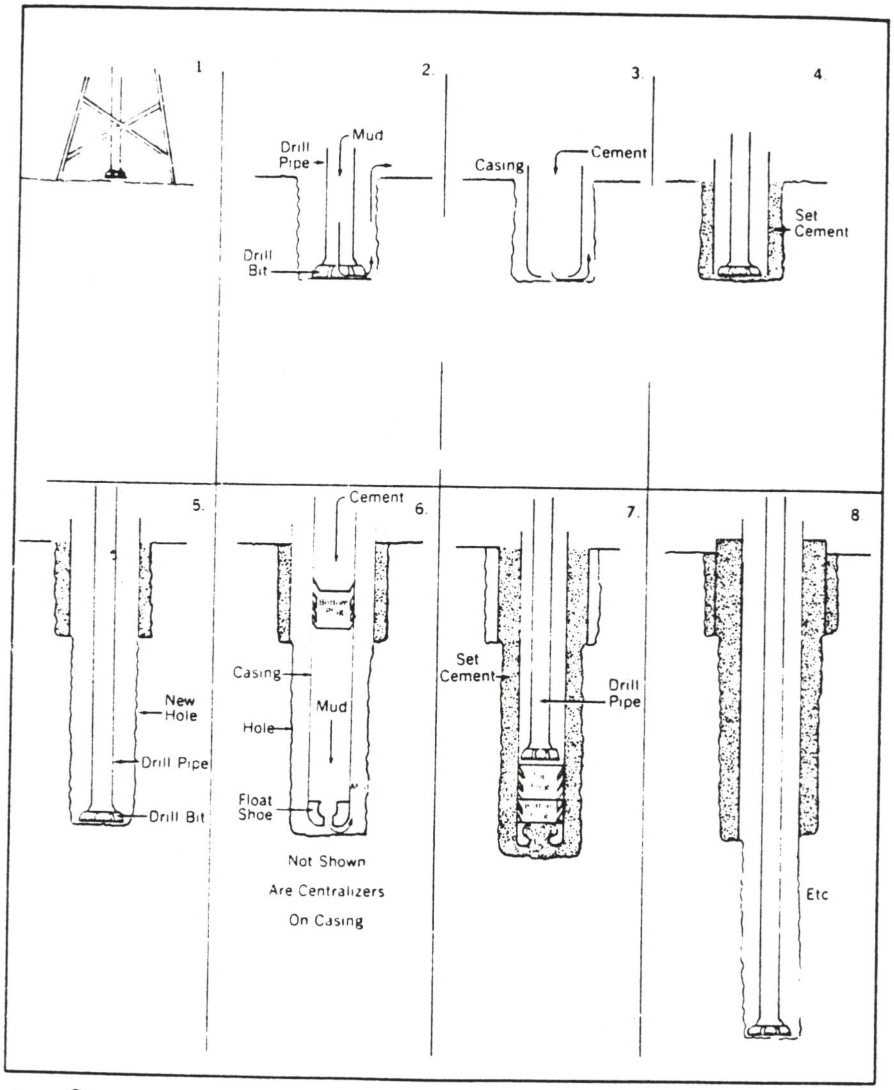
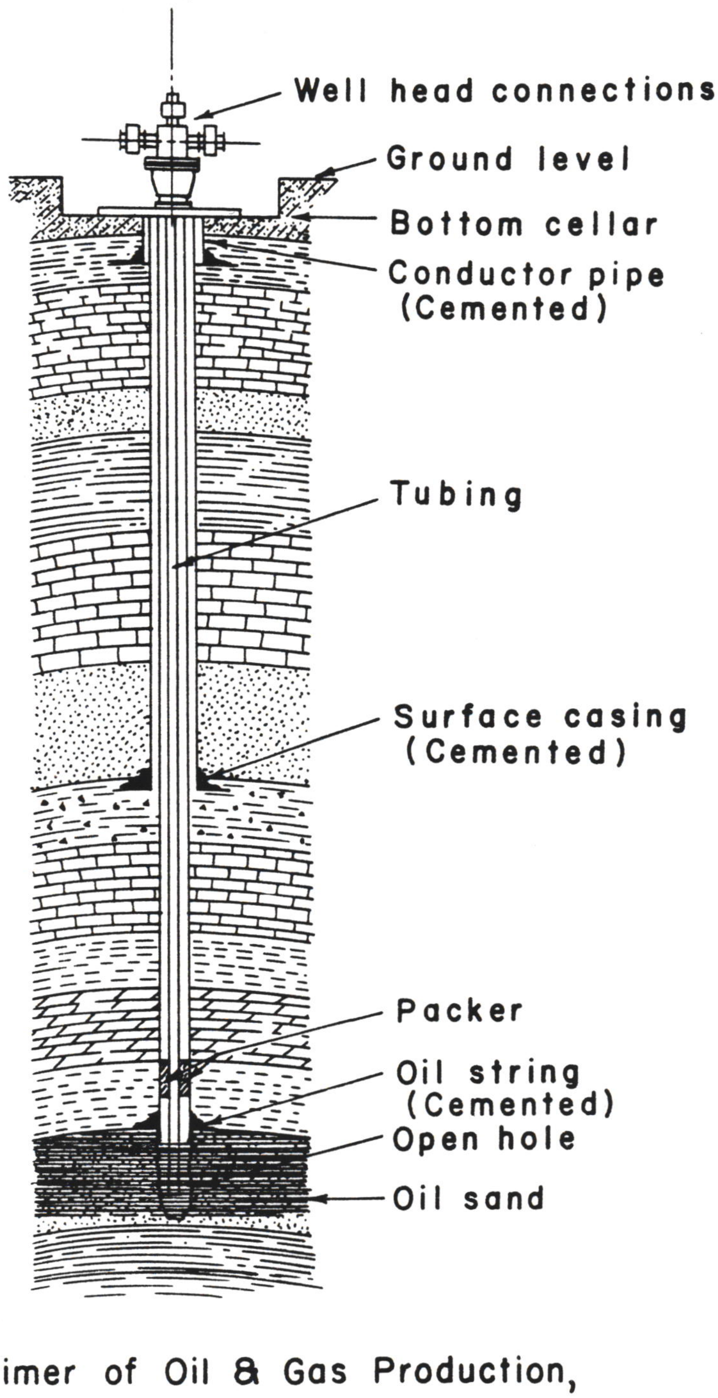


Fig. 2 Casing/cementing procedure. (courtesy The Western Co. of North America)

FIGURE 3

WELL CUTAWAY VIEW



Source: Primer of Oil & Gas Production, American Petroleum Institute, 1978.

gas in a "pay zone" to warrant completion of the well. Drill stem testing is often done at this stage to better determine whether a formation will be productive. The drill string is run in the hole and serves as a conduit through which fluids from the formation can flow to the surface for pressure testing while isolating the column of drilling fluid. If the formation produces oil or gas, the area may be developed. If the formation does not produce, the well may either be extended to a greater depth or abandoned.

Well completion involves installation of steel casing from the surface to the bottom through the surface casing and the pay zone. The casing is cemented bottom to top to provide stability and to protect specific zones, and then perforated adjacent to the suspected producing formation.

In 1984 a total of 268 exploratory wells were drilled in Montana, a slight increase over 1983, but less than half the number drilled during the exploration boom of 1981. Over the past few years, approximately 30 percent of the exploratory wildcat wells drilled in Montana have been productive. This rate is slightly better than average. Another measure of drilling activity is the number of rigs operating in the state. Nationally, the number of operating rigs is down 27 percent compared to 1984; in Montana the number is down 53 percent (Ballard, 1985). The number of seismic crews operating nationally is down 50 percent from 1981 levels (D'Amico, 1985). This trend is primarily determined by lower crude oil prices, and also by factors such as taxes, tight credit and a tendency toward corporate mergers within the industry that has reduced availability of funds for exploration. Of 93,048,320 total acres in Montana, 47 percent is currently leased for oil and gas exploration, although less than 2 percent of that amount has actually been developed (Ballard 1985).

Development

If a wildcat well becomes a "discovery" well (i.e., if it yields commercial quantities of oil and gas), other wells ("development" wells) are drilled to locate the boundaries of the field and establish the best pattern of wells to drain the reservoir.

If a well is completed as a free-flowing oil well, the wellhead is simply closed off using a device known as a "Christmas tree" which consists of various valves and pressure regulators designed to control oil and gas flow to facilities used in the production phase. If the well is a gas discovery, the operator is allowed to flare gas for a short period of time to determine capacity before shutting the well in or connecting the well to gas gathering pipelines.

Oil and gas field size may vary from less than 1,000 acres to several thousand acres, and some cover several townships. The Board of Oil and Gas Conservation regulates the spacing of oil and gas wells. In the absence of special field rules, the regulations require oil wells less than 6,000 feet deep to be placed one per 40 acres; oil wells 6,000-11,000 feet, one per 160 acres; wells greater than 11,000 feet deep, one per 320 acres. Gas wells are located one well per 640 acres. However, producing fields in Montana are usually not square-shaped blocks. They are more typically narrow (1/4 mile wide) tracts that may wander and/or extend for several miles. If an oil field is developed on the current minimum spacing pattern of 40 acres per well and if the field is a section (640 acres) in size, it can be estimated that at least four miles of roads will be needed (USDA 1979). In addition to roads, other surface development includes well drill sites, flowlines, on-site processing facilities to separate oil, gas and water, storage tank batteries, and in larger fields, gathering and transmission pipelines (see Figure 4). Gathering lines transport the oil and/or gas from the well site to collection facilities while transmission lines move it from storage to refineries or gas utility systems. Other facilities that may be present include injection wells for salt water disposal or evaporation pits. Many fields go through several development phases. A field may be considered fully developed and produce for several years, then wells may be drilled to a deeper pay zone, thus creating a new field beneath the old field.

In 1984, 533 development wells were drilled in Montana, including 327 oil wells, 99 gas wells and the rest either dry holes or service wells. This overall total is considerably higher than 1983's total of 313 wells, while the number of oil wells drilled in 1984 is the highest in any recent year. The percentage of total wells drilled by region in Montana in 1984, including both development and exploratory oil and gas wells, as well as dry holes and service wells are as follows (Montana Oil and Gas Conservation Division 1985):

Northern	48.4 (%)
Williston Basin	37.5
Central	7.9
Powder River	2.5
Big Horn	2.4
Overthrust	1.4

Production

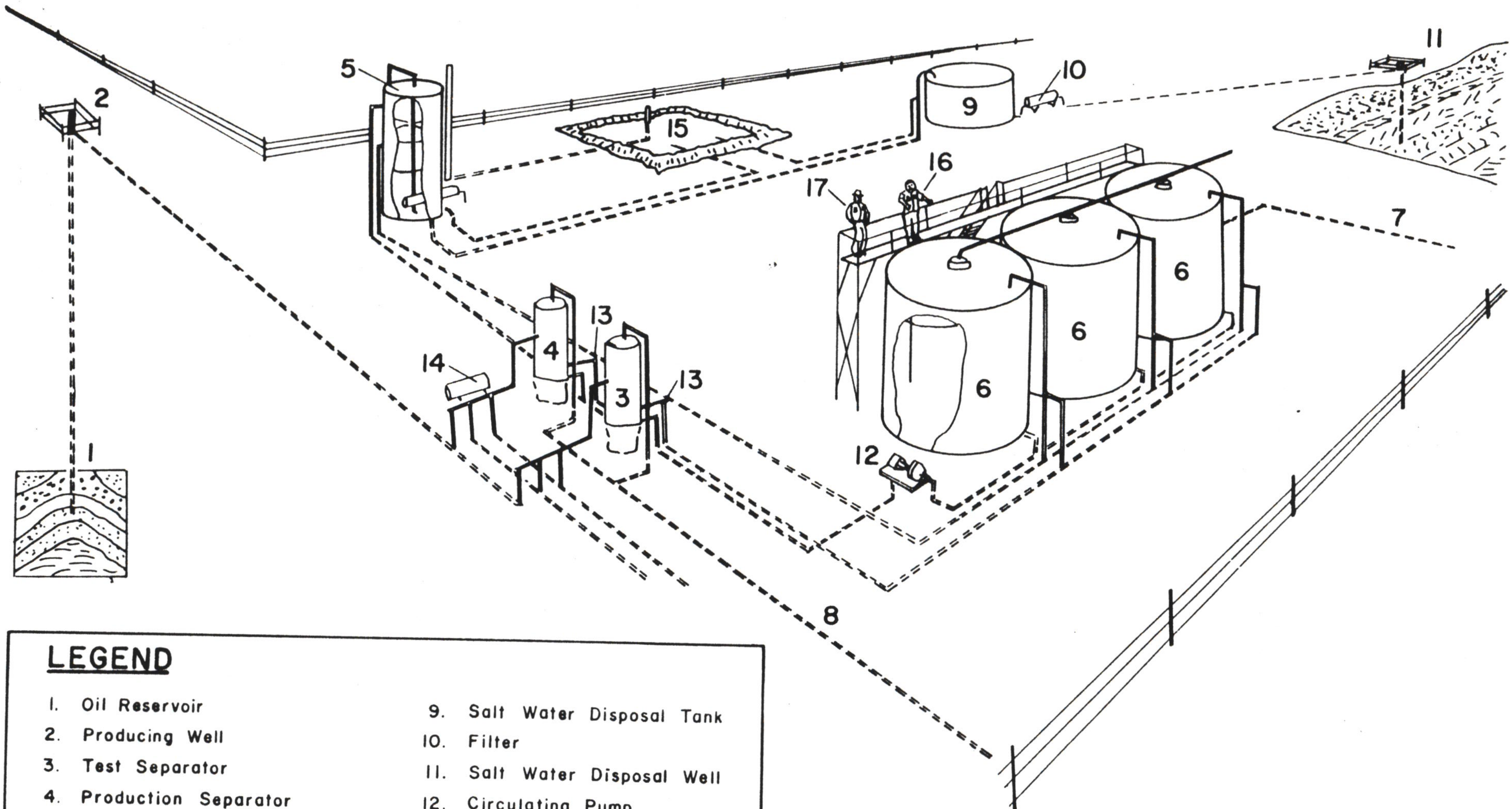
Production begins soon after the discovery well is completed and often concurrently with development operations. The extent of facilities is dictated by the number of producing wells, expected production, volume of gas and water produced with the oil, the number of leases, and whether the field is to be developed as a unit or by various individual well owners.

The Process

Production in a gas field does not begin until the pipeline to a market has been constructed. Sales pipelines are not justified until

FIGURE 4

FLOWING OIL PRODUCTION



LEGEND

1. Oil Reservoir
2. Producing Well
3. Test Separator
4. Production Separator
5. Flow Treater
6. Stock Tank
7. Crude Oil Gathering Line
8. Gas to Gasoline Plant, Sales, or other uses
9. Salt Water Disposal Tank
10. Filter
11. Salt Water Disposal Well
12. Circulating Pump
13. Gas Meter
14. Chemical Injection
15. Emergency Salt Water Pit
16. Pipeline Gauger
17. Lease Pumper

Source: U. S. Department of Interior, 1963.

sufficient gas reserves are proved by drilling operations. Gas wells are often shut-in after completion for periods ranging from months to years until markets exist or pipeline connections are available.

If the natural gas contains hydrogen sulfide (H2S), special handling and worker safety precautions are required. For example, high carbon steel is used for drilling and casing deep holes due to its strength, but it will shatter like glass if exposed to high concentrations of H2S. The H2S must be removed before the gas enters a commercial pipeline because it is highly corrosive. If gas containing H2S is produced in quantities insufficient to justify removal, it is flared. If combustion during flaring is complete, only sulfur dioxide is emitted into the air. However, if incomplete combustion occurs, other sulfur compounds including H2S are emitted into the air. Oil wells producing from formations containing H2S represent a hazard to personnel if dissolved H2S is present in the oil.

The Overthrust Belt gas discoveries in Montana and Wyoming appear to be producing "sour" gas (FWP 1983). The term "sour gas" refers to sulfur content, including both sulfur dioxide and H2S. The process of removing high concentrations of H2S from gas can require very large, complex facilities which can cost several hundred million dollars (USDI 1980). However, such facilities are designed to handle several hundred million cubic feet of gas per day. The American Natural Resources Company's "Stateline" plant near Sidney, which the EQC visited on its tour in October, is one of the largest gas treatment facilities in Montana. It includes facilities for separating out butane and propane as well as removing hydrogen sulfide. Facilities consisting of only a few treatment vessels can suffice for removing low concentrations of H2S from relatively low volumes of gas (i.e., a few thousand cubic feet per day).

While natural gas is often sold at the wellhead and piped directly off the site, it may first be transferred to a nearby collection point prior to sale, especially if processing is required to remove liquid hydrocarbons or water. "Condensate" or "casinghead gas" is the volatile liquid that condenses as the gas comes out of the well. If enough of this gas is separated in the field to make it economical to process for marketing, a plant may be built to remove gasoline, butane, and propane. Some of the gas is used to fuel the plant and the remainder is sold. If the volume of casinghead gas produced in a field is insufficient to warrant treatment in a gas plant, it is usually used as fuel for pump engines in the field and as heating fuel for oil treaters. If the gas exceeds fuel requirements, it may be flared or vented to the atmosphere.

Crude oil is usually transferred from wells to a central storage tank battery before it is transported from the site by truck or by pipeline. If the oil contains gas and water (known as produced water), separation is necessary and is usually accomplished using heat and chemical emulsion breakers before the oil is stored. The treating facilities are usually located at a storage tank battery. There are normally at least two storage tanks so that one tank can be filled as the contents of the other are measured, sold and tranported.

Produced Water

Most "produced waters" are brackish to highly saline. Methods of disposal include storage in earthen pits, discharge to surface waters (which requires a permit under the Montana Pollution Discharge Elimination System) or underground injection. When salt water is disposed of underground, it is usually introduced into a formation containing water of equal or poorer quality. It may be injected into the producing zone from which it came or it may be hauled by truck to a licensed disposal facility. In some cases, water injection or "flooding" stimulates oil production. In other cases, it could reduce the field's productivity and may be prohibited by state regulation or mutual agreement of the operators. Cement is squeezed between the casing and sides of an injection well to prevent the salt water from migrating up or down from the injection zone into other formations.

Measures to Enhance Recovery

In some cases, formation fracturing ("fracting") is used to increase the permeability of the producing formation and thereby stimulate production. Under extremely high hydraulic pressure, a fluid (such as water, oil, alcohol, dilute hydrochloric acid, liquefied petroleum gas, or foam) is pumped downward through tubing or drill pipe and forced into the perforations in the casing. The fluid enters the formation and parts or fractures it. Sand grains, aluminum pellets, glass beads, or similar materials are carried in suspension by the fluid into the fractures. These are called propping agents or proppants. When the pressure is released at the surface, the fracturing fluid returns to the well, and the fractures partially close on the proppants, leaving channels for oil to flow through to the well.

Most oil wells in Montana (up to 90 percent) require artifical pumping or other lift techniques to bring the oil to the surface. The horsehead pump is most commonly used. This primary production may account for recovery of 20-25 percent of the oil in a reservoir. Where economically and geologically feasible, "secondary" recovery methods are used. This involves pumping water or gas into the reservoir to increase oil production by increasing the pressure in the reservoir. The water supply is usually a brine obtained by drilling in the waterflood area. Fresh water is not desirable for waterflood purposes because it may form chemical bonds with clays in some reservoir rocks and reduce the permeability of the reservoir. In 1984 over 40 fields in Montana were undergoing secondary recovery (DNRC 1985). Most secondary recovery projects employ water flooding methods. Secondary recovery projects can result in production of another 15-20 percent of the original oil in place.

"Tertiary" recovery methods can sometimes increase recovery rates if the viscosity of the oil is lowered so that it flows more easily. This can be accomplished either by heating the oil with steam or by injecting chemicals such as polymers and surfactants into the reservoir (USDI 1981). Tertiary recovery methods are expensive and most are still in the experimental stage, although as of 1984, ten tertiary recovery projects had been undertaken in Montana. The effectiveness of the tertiary recovery methods is variable, but they can improve overall oil recovery by an additional 10-15 percent and increase the productive life of certain types of reservoirs.

In October 1985, the Department of Natural Resources and Conservation published a draft environmental impact statement on a carbon dioxide pipeline proposed by Exxon Pipeline Company that would extend from a point near Green River, Wyoming and pass through portions of Powder River, Carter and Fallon counties in Montana and terminate at a point near Tioga, North Dakota. The Shell Pipeline Company is a potential purchaser of the CO_2 and may build a 65-mile pipeline from Baker to its eastern Montana fields, including the Cedar Creek Anticline, for use in tertiary recovery projects. The final EIS on this project will be published in February. It will be a joint federal-state document.

Pipelines are needed to transport oil from gathering stations to refineries and gas from the wellhead or processing facilities to utilities. The existing pipeline network in Montana is shown on the map included at the beginning of this overview. New pipelines are needed as existing fields increase production or new fields begin production. Length varies tremendously based on proximity of new fields to existing pipelines, available capacity in the pipeline system and ultimate destinations of the oil/gas.

Abandonment

Well plugging requirements vary with the rock formations, subsurface water characteristics, and the type of well. Generally, the hole is filled with heavy drilling mud to the bottom of the cemented casing in order to plug a well that is depleted. A cement plug is installed at the bottom of the casing and in the perforated section of the producing zone. A cement cap is installed on top. Protection of aquifers and known oil and gas producing formations may require placement of additional cement plugs.

After plugging, the drilling rig is removed and the surface, including the reserve mudpit, is restored. Specific federal and state regulation of abandonment practices varies. In some cases, wells are plugged as soon as they are depleted. In others, depleted wells are not plugged immediately but are allowed to stand idle for possible later use in a secondary recovery program.

When an entire field is abandoned, the separators, treaters, and other processing and handling equipment are removed and the surface restored. Surface flow and injection lines are removed but buried lines are usually left in place and plugged at intervals as a safety measure.

Environmental Impacts

The impacts of oil and gas exploration and development upon the environment may range from exceedingly minor to significant, depending on case by case circumstances and site specific characteristics. Table 2 presents a list of resource values which are affected by different phases of exploration, development and production (USDA 1979).

Air quality is affected by all active phases of oil and gas exploration and development. The primary air pollutants come from dust generated by vehicles on roads and around drilling sites and emissions from vehicles and stationary engines used in the drilling operation. In the production phase, air pollutants can be produced from separation facilities, flaring of unwanted gas and by venting of noxious vapors from storage tanks. Also, accidental explosions, fires, blowouts, and leaks can occur (USDA 1979).

Serious problems can develop when working with sour gas which contains highly toxic and flammable H2S. H2S can represent a deadly hazard to personnel, and requires special safety procedures.

Soil productivity and capability can be adversely affected wherever the earth's surface is disturbed. Soil compaction and surface erosion are common problems that are primarily caused by use of mechanized equipment. These adverse impacts can often be mitigated but their extent and severity is highly dependent on the type of terrain to be crossed, the location of access roads, and construction practices. Mass movement stability hazards such as potential landslides, avalanches, rockfalls, and earthflows can occur if they are not identified and corrective measures taken. When soil is destroyed, the vegetation dependent upon it is also destroyed.

Construction of roads and facilities is the primary impact on vegetation. Wildfire, which may occur accidentally during any of the phases of oil and gas exploration and development, may cause destruction of considerable vegetation, and eventual erosion and degradation of soils and water quality. Most companies, however, make a reasonable commitment to fire control.

Adverse effects of oil and gas exploration and development on fish and wildlife can vary immensely due to the diversity of species and their habitat needs. Potential impacts may include the following (USDI 1981): (1) Surface disturbance generally reduces the quantity and quality of forage and cover. (2) Short or long term displacement of wildlife and stress to wildlife can occur as a result of disturbance and noise. (3) Increased access can cause hunting and fishing pressure to increase, and an increase in nonconsumptive recreational use of an area with attendant stress and displacement impacts. (4) If road closures are necessary,

Table 2. Oil and gas activities and affected resource values - oil and gas activity effects.*

Values	Preliminary exploration	Exploratory drilling	Development	Production	Abandonment
Air quality	x	x	x	x	x
Soil - compaction	x	x	x	x	N/A
erosion	x	x	x	x	N/A
mantle stability	x	x	x	x	N/A
Water - sedimentation	x	x	x	x	N/A
surface water contamination	N/A	x	x	x	x
ground water contamination	N/A	x	x	x	N/A
Geological hazards - subsidence	N/A	N/A	N/A	x	N/A
seismicity	N/A	x	x	x	N/A
Cultural values	x	x	x	N/A	N/A
Visual quality	x	x	x	x	N/A
Recreation - developed areas	x	x	x	x	N/A
recreation types	x	x	x	x	N/A
Fish	x	x	x	x	x
Socioeconomics	x	x	x	x	x
Wildlife	x	x	x	x	x

*Adapted from USDA Forest Service, Region 1, Oil & Gas Guide.

management costs and enforcement requirements increase. (5) Direct mortality to wildlife can result from the operation of equipment and machinery, primarily due to vehicle/wildlife collisions. (6) Vegetation removal and soil disturbances along streams for the purpose of access road construction can alter streamflow patterns, raise water temperature, decrease insect production and increase siltation levels.

Water quality can be adversely affected during all phases of oil and gas exploration and development. Abnormal sedimentation usually results from erosion where roads and trails cross streams. This is particularly common in the exploration phase and in the production phase when high grade roads, drill pads, processing facilities and pipelines are constructed. Surface water contamination may occur from leaks in reserve and evaporation pits, oil spills, produced water and rare instances of blowouts. Groundwater contamination may occur from surface leaching, introduction of well fluids into groundwater aquifers, or spills from buried pipelines (USDA 1979). Interconnection of aquifers of varying water quality can occur, especially if abandoned holes are improperly plugged. The chemically-based methods of tertiary oil recovery can also be a source of groundwater contamination, especially if a reservoir is permeable and the solutions are able to migrate out (Yellowstone-Tongue APO, 1977). The Board of Oil and Gas Conservation has adopted a number of rules concerning drilling and well or test hole plugging procedures that are intended to protect water quality.

The most likely potential geological hazards are those associated with surface soil movement (landslides, mud flows).

Cultural values, including archaeological and historical sites, may be adversely affected by any surface disturbing activity. On federal lands a cultural resource inventory of the entire area that will be disturbed is required. The Montana Antiquities Act requires consultation with the historic preservation officer in order to identify and locate any properties or remains on state-owned lands that may be affected.

The visual quality (aesthetics) of an area will be affected during all phases of activity, especially from the perspective of those who place priority on undisturbed, natural landscapes.

Any of the phases of oil and gas activity can affect recreational pursuits such as hiking, camping, ski touring, snowmobiling, hunting, fishing, picnicking, pleasure driving or boating. The development of additional access (roads) into an area can improve or impair recreational pursuits depending on the expectations of persons using the area and factors such as historic recreational use. More access can change the types of recreational uses available.

Social and economic impacts of oil and gas development, can be both positive and negative. Many variable conditions govern the scope and severity of socio-economic impacts; however, size of the discovery and specific location are the two most crucial factors (USDA 1979). The larger the field and the more isolated the field is from an existing area of high population density, the more prominent the impacts can become. In the case of a large field being discovered far from any large towns, the following impacts are probable: positive economic impacts would result as significant numbers of new jobs become available. The influx of large amounts of new money into an area boosts the local economy. The tax bases of local areas, counties and the state would be enriched. Negative economic impacts that may be encountered are the burdens placed on community and county infrastructure, which include housing, water supply, sewage treatment, schools, recreational opportunities, roads and police and fire protection. Both positive and negative impacts are usually lessened if development occurs in proximity to more populous areas, except possibly for some safety-related considerations. Social impacts are more difficult to analyze. Changes of life style are likely in varying degress, again depending on the number of persons residing in an area slated for development. Adverse impacts such as an increase in violent crime, drug abuse and various forms of family and social disruption can offset beneficial financial impacts (MDSL 1981).

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PART II: SUMMARY OF ENVIRONMENTAL LAWS AND REGULATIONS RELATING TO OIL AND GAS ACTIVITY

Montana environmental laws address the entire oil and gas development process, from exploration to production to abandonment. This authority is implemented primarily by two entities: the Board of Oil and Gas Conservation and the Department of Health and Environmental Sciences. The Board of Oil and Gas Conservation has principal jurisdiction over oil and gas activity. The Department of Health and Environmental Sciences is involved when the activity significantly affects water or air quality.

Two other agencies have authority in specific instances. The Department of State Lands is involved when it enters into lease arrangements for oil and gas activity on lands under its administration. The Department of Fish, Wildlife and Parks is similarly involved in regard to development on its lands; in 1981 it prepared a programmatic environmental impact statement to address such development.

This part addresses the authority of the Board of Oil and Gas Conservation (Board) and the Department of Health and Environmental Sciences (DHES). Only the laws and regulations specific to the Board and DHES are discussed; Montana Environmental Policy Act implications are not addressed.

Geophysical Exploration

A. Notice and Exploratory Permit Requirements

Title 82, chapter 1, MCA, addresses geophysical exploration. While requirements for abandonment and reclamation are specified, agreements between the surface owner and seismic operator are the principal means used to specify restrictions on surface exploration activity. The law does require registration of seismic crews operating in the state and the filing of a notice of intention to explore with the county clerk and recorder in the county in which exploration will occur (82-1-103). Upon receipt of a certificate specifying the name of a registered agent and verifying the attainment of a surety bond, the county clerk and recorder issues a geophysical exploration permit (82-1-106). The surety bond, which is either $10,000 or $25,000 depending on the number of crews operated by the explorer in the state, is required in order to indemnify owners of property from physical damages that could occur as a result of seismic operation (82-1-104).

B. Available Government Actions

The county clerk and recorder, upon the complaint of a property owner that physical damage has occurred to his property from seismic operations, may require information concerning shotpoints within areas up to 4-sections (82-1-108). In addition, the county attorney is authorized to to take actions, which can include revocation of the permit, to ensure compliance with the requirements of Title 82, chapter 1 (82-1-109; ARM 36.22.503). Violations are referred to the county attorney by Board staff.

C. Abandonment Requirements

Abandonment requirements for geophysical exploration activity include the plugging of all "shot holes" such that any water within the underlying strata is contained by use of bentonite mud, cement, or other material, and the capping of the hole at a depth sufficiently below the surface to allow cultivation. In addition, the explorer must remove all ropes and other debris and restore the surface to its previous grade and productive capability. The specific implementation of these requirements is subject to an agreement between the surface owner and explorer, though Board or Board staff approval is needed if the proposed restoration plan varies from the above requirements (compare 82-1-104(2) with 82-11-123(4), MCA).

Drilling

A. The Permit Requirement

A permit to drill is required before either exploratory or production drilling is undertaken. Section 82-11-122 states:

> "It is unlawful to commence the drilling of a well for oil or gas without first filing with the board written notice of intention to drill and obtaining a drilling permit as provided in 82-11-134...."

Section 82-11-134 states that a permit must be obtained and that a fee must be paid:

> "In addition to the privilege and license tax, before commencing the drilling of an oil or gas well or stratigraphic test well or core hole, a person shall secure from the board a drilling permit and shall pay to the board therefore the following amounts:
> (1) for each well whose estimated depth is 3,500 feet or less, $25;
> (2) from 3,501 feet to 7,000 feet, $75;
> (3) 7,000 feet and deeper, $150.

The statutes do not clearly specify what requirements may be attached to a permit. The Board of Oil and Gas Conservation approves permit applications upon submission of a Form 2 application (see attachment 1) with the fee and an accurate plat. Form 2 does specify eleven conditions, however, including a condition stating that all work must be performed in conformity with rules adopted by the Board.

Permits to drill are occasionally given more detailed attention by the Board. The SOHIO application for a permit to drill a well in Bridger

Canyon received relatively extensive analysis, including a special public hearing requested by SOHIO and concerned citizens. As a result, the Board issued a permit containing several specific conditions based on a preliminary environmental review. Included among these conditions were measures to ensure the quality of the ground water supply and to provide protection from hydrogen sulfide blowout.

The Board's rules specifically provide for the attachment of special conditions after notice and hearing on a permit application to drill or an approval of recompletion operations if any of the applicant's other Montana operations is not in substantial compliance with the Board's rules (ARM 36.22.601). This process has, however, been used infrequently. The rules do not address the attachment of special conditions when the applicant's existing operations are in substantial compliance with Board rules.

B. The Disposal of Drilling Wastes

The statutes specifically address drilling wastes. The Board is granted authority under 82-11-111 to require "measures to be taken to prevent contamination of or damage to surrounding land or underground strata caused by drilling operations....." ARM 36.22.1005 is based on this authority and authority provided in 82-11-123 and -124:

> "(1) The operator of a drilling well shall contain and dispose of all solid waste that accumulates during drilling operations. Said waste shall either be removed from the well site or buried at the well site to a minimum depth of 3 feet below the restored surface of the land.
> (2) The operator of a drilling well shall construct his reserve pit in a manner adequate to prevent undue harm to the soil or natural water in the area. When a salt base mud system is used as the drilling medium, the reserve pit shall be sealed when necessary to prevent seepage."

Reserve pit liners are used frequently as a means of preventing seepage, particularly where the underlying soil is permeable.

C. Other Drilling Requirements

Section 82-11-123, MCA provides the Board with authority to require casing and other measures to protect aquifers and oil or gas reservoirs from contamination from salt or brackish water, muds, or oil or gas. For rotary drilling, surface casing must be set to a depth below all potable fresh water which is reasonably accessible for agricultural or domestic use. In addition, only freshwater based drilling fluid may be used when drilling is occurring through freshwater aquifers (ARM 36.22.1001). Similar casing and drilling requirements exist for cable drilling (ARM 36.22.1002).

D. Enforcement Responsibilities

The Board has authority to enforce its laws under 82-11-147 and -148, MCA. In addition, the DHES uses its authority to make reactive responses to oil and gas-related pollution occurrences. Because of the Board's principal authority over oil and gas development, however, reserve pits (along with water injection wells and produced water pits) are specifically exempted from DHES' Groundwater Pollution Control System permit requirements.

Authority for DHES responses to incidences of ground water contamination, regardless of the cause, exists under Title 75, Part 6, MCA. The DHES may inspect facilities to determine if contamination exists (75-5-603), issue cleanup order (75-5-615), seek injunctions (75-5-614), and collect for costs of cleanup efforts undertaken by the Water Quality Bureau (75-5-635).

Production

A. Waste Prohibition

Title 82, chapter 11, MCA (Oil and Gas Conservation) is the Board's principal authority for regulating oil and gas production. The prevention of waste of oil and gas is the major objective of this chapter, and potentials for waste are greatest during the production phase. Waste is defined in 82-11-101(12) to mean:

> "(a) physical waste, as that term is generally understood in the oil and gas industry;
> (b) the inefficient, excessive, or improper use of or the unnecessary dissipation of reservoir energy;
> (c) the location, spacing, drilling, equipping, operating, or producing of any oil or gas well or wells in a manner which causes or tends to cause reduction in the quantity of oil or gas ultimately recoverable from a pool under prudent and proper operations or which causes or tends to cause unnecessary or excessive surface loss or destruction of oil or gas; and
> (d) the inefficient storing of oil or gas. (The production of oil or gas from any pool or by any well to the full extent that the well or pool can be produced in accordance with methods designed to result in maximum ultimate recovery, as determined by the board, is not waste within the meaning of the definition.)"

Section 82-11-121 then states: "Waste of oil or gas or either of them as waste is defined in this chapter is prohibited (emphasis added)."

References to waste of oil and gas and to the disposal of salt water and oil field wastes are also addressed in the Board's powers and duties:

"(1) The board shall make such investigations as it considers proper to determine whether waste exists or is imminent or whether other facts exist which justify any action by the board under the authority granted by this chapter with respect thereto.

(2) Subject to the administrative control of the department (of Natural Resources and Conservation) under 2-15-121, the board shall:

(a) require measures to be taken to prevent contamination of or damage to surrounding land or underground strata caused by drilling operations and prodcution, including but not limited to regulating the disposal of salt water and oil field wastes;

(b) classify wells as oil or gas for purposes material to the interpretation or enforcement of this chapter;

(c) adopt and enforce rules and orders to effectuate the purposes and intent of this chapter...... (82-11-111)."

Finally, section 82-11-124 provides requirements relating to waste prevention. The most applicable part of this section reads:

"Subject to the administrative control of the department (of Natural Resources and Conservation) under 2-15-124, the board shall, for the purpose of preventing waste:

(1) regulate the drilling, producing, and plugging of wells, the shooting and chemical treatment of wells, the spacing of wells, operations voluntarily entered into to increase ultimate recovery such as cycling of gas, the maintenance of pressure, and the introduction of gas, water, or other substances into production formations;....."

While the primary purpose of the waste statutes appears to be wise and efficient use of the available oil and gas reserves, the statutory requirements also offer environmental protections because the reduction of oil or gas waste results in lower levels of environmental contamination from these resources. In addition, section 82-11-111 provides the Board with authority over the disposal of salt water and oil field wastes.

B. Salt (Produced) Water Disposal

The Board provides specific guidance by rule on the disposal of salt or brackish water separated on site from the crude oil. Section 36.22.1227 prescribes measures for the disposal of salt or brackish water in earthen pits:

"(1) Salt or brackish water may be disposed of by evaporation when impounded in excavated earthen pits which may only be used for such purpose when the pit is underlaid by tight soil such as heavy clay or hardpan.

(2) Where the soil under the pit is porous and closely underlaid by a gravel or sand stratum, impounding of salt or brackish water in such earthen pits is hereby prohibited.

(3) The board shall have authority to condemn any pit which does not properly impound such water.
(4) At no time shall salt or brackish water impounded in earthen pits be allowed to excape over adjacent lands or into streams."

Section 36.22.1228 addresses disposal of salt or brackish water by injection:

"Salt water may be disposed of by injection into the strata from which produced or other proven salt water bearing strata by the procedure outlined in ARM 36.22.1229 through 36.22.1234, except approval may be obtained by administrative order without hearing unless objections are received by the board within 10 days after the application is filed."

Section 36.22.1229 requires sound casing to protect leakage, and sound casing and cement through areas which contain oil, gas, or fresh water reservoirs. Sections 36.22.1230 and -.1231 detail requirements for applications, for giving notice of applications, and for objecting to applications. Section 36.22.1232 requires board approval of water flood or gas injection programs, and section 36.22.1233 specifies that abandonment and plugging requirements shall follow the requirments provided for oil and gas drilling and production wells.

The DHES approaches produced water in a manner similar to drilling wastes. Produced water (or disposal) pits are exempted from the Groundwater Pollution Control System permit requirements (ARM 16.20.916), but if contamination occurs the same remedies are available as described earlier. In addition, if the operator desires to discharge produced waters to surface water drainages, a permit is required under the Montana Pollution Discharge Elimination System (MPDES). Thirty-eight permits for this purpose have been issued by the Water Quality Bureau over the last ten years.

Water disposal wells are exempted from Groundwater Pollution Control System permitting requirements, provided "it has been determined that such injection or disposal will not result in the degradation of ground or surface water resources" (ARM 16.20.916). The federal Environmental Protection Agency, however, administers an underground injection control program in Montana that is aimed at preventing contamination of aquifers from leaking injection wells.

C. Other Requirements

Section 82-11-123(3), MCA provides that the Board shall require fro oil and gas operators:

"the drilling, casing, producing, and plugging of wells in such manner as to prevent the escape of oil or gas out of one stratum into another, the intrusion of water into oi or gas stratum, blowouts, cavings, seepages, and fires and the pollution of fresh water supplies by oil, gas, salt, or brackish water;"

Based on this authority and sections 82-11-111 and -123, tubing is required in all flowing oil wells except those which are dual completions (ARM 36.22.1206). In addition, all flowing oil wells must have chokes or similar equipment which ensure proper and safe operations during normal production practices (ARM 36.22.1203).

DHES has expressed some concern about the cumulative effects of flaring natural gas from oil wells. Flaring at individual well sites, however, is beneath the threshold level of 25 tons per year of any pollutant necessary to fall under air quality permitting requirements (ARM 16.8.1102).

Board regulations require justification by the operator if he wishes to flare more than 100 MCFG per day (ARM 36.22.1220). Justification includes establishing that it is not economically feasible to market the gas. In addition, all waste gas vented to the atmosphere at a rate exceeding 20 MCF per day for 72 hours or more must be burned. If the gas contains 20 or more parts per million of hydrogen sulfide, workable igniter systems must be installed to further ensure that waste gas will be burned (ARM 36.22.1221).

Well Abandonment

Part 4 of Title 82, section 10, MCA addresses the reclamation of abandoned oil or gas wells in regard to surface owners. The surface owner may at his option require that the well pipe for a well be buried to a depth of not less than 3 feet (82-10-401). In addition, Board staff are required to:

> "maintain a list of the abandoned oil or gas wells, injection wells, sumps, and seismographic shot holes in the state which disturb land, water or wildlife resources to a degree not in compliance with plugging, pollution prevention, and reclamation rules of the board....." (82-10-402).

The Board is further directed under 82-11-123, MCA, to require:

> "......(4) the restoration of surface lands to their previous grade and productive capability after a well is plugged or a seismographic shot hole has been utilized and necessary measures to prevent adverse hydrological effects from such well or hole, unless the surface owner agrees in writing, with the approval of the board or its representatives, to a different plan of restoration;
> (5) the furnishing of a reasonable bond with good and sufficient surety, condition for performance of the duty to properlty plug each dry or abandoned well;....."

Under the authority provided above and from 82-10-401, 82-11-111, and 82-11-124, the Board has adopted a subchapter addressing well abandonment requirements (ARM 36.22.1301 to -.1309). These requirements provide for notice of abandonment to the surface owner and to the Board or the Board's petroleum engineer, actual plugging of the well according to specific requirements (except if it can be used as a fresh water well), restoration of the surface, measures to prevent adverse hydrologic effects, and a subsequent report to the Board on abandonment. These requirements are supported by a bond requirement of $5,000 if the well owner has only one well in the state or $10,000 if he has more than one well (ARM 36.22.1308).

Attachment 1

Form No. 2 R 4-84

NOTICE
THIS FORM BECOMES A PERMIT WHEN STAMPED APPROVED BY AN AGENT OF THE BOARD.

(SUBMIT IN QUADRUPLICATE)
TO

BOARD OF OIL AND GAS CONSERVATION
OF THE STATE OF MONTANA
BILLINGS OR SHELBY

ARM 36.22.307 ARM 36.22.601 ARM 36.22.602 ARM 36.22.603 ARM 36.22.604 ARM 36.22.605
ARM 36.22.1003 ARM 36.22.1004 ARM 36.22.1013 ARM 36.22.1301 ARM 36.22.1306 ARM 36.22.1309

SUNDRY NOTICES AND REPORT OF WELLS

Notice of Intention to Drill *		Subsequent Report of Water Shut-off	
Notice of Intention to Change Plans		Subsequent Report of Shooting, Acidizing, Cementing	
Notice of Intention to Test Water Shut-off		Subsequent Report of Altering Casing	
Notice of Intention to Redrill or Repair Well		Subsequent Report of Redrilling or Repair	
Notice of Intention to Shoot, Acidize, or Cement		Subsequent Report of Abandonment	
Notice of Intention to Pull or Alter Casing		Supplementary Well History	
Notice of Intention to Abandon Well		Report of Fracturing	

(Indicate Above by Check Mark Nature of Report, Notice, or Other Data)

...., 19......

Following is a {notice of intention to do work / report of work done} on land {owned / leased} described as follows:

LEASE ....

.... MONTANA ....
(State) (County) (Field)

Well No. ....
(m. sec.) (Township) (Range) (Meridian)

The well is located .... ft. from {N / S} line and .... ft. from {E / W} line of Sec. ....

* For notice of intention to drill, write the API# or the well name of another well on this lease if one exists ____________

LOCATE WELL SITE ACCURATELY ON PLAT ON BACK OF THIS FORM.

The elevation of the ground or K.B. above the sea level is ....

READ CAREFULLY **DETAILS OF PLAN OF WORK** READ CAREFULLY

(State names of and expected depths to objective sands; show size, weights, and lengths of proposed casings, cementing points, and all other important proposed work, particularly all details of Shooting, Acidizing, Fracturing.)

DETAILS OF WORK
RESULT

Approved subject to conditions on reverse of form

Date ....

By ....
District Office Agent Title

Company ....

By ....

Title ....

Address ....

BOARD USE ONLY
API WELL NUMBER
2 5
STATE COUNTY WELL

NOTE:—Reports on this form to be submitted to the appropriate District for approval.
DRILLING PERMIT EXPIRES SIX MONTHS FROM DATE OF APPROVAL.

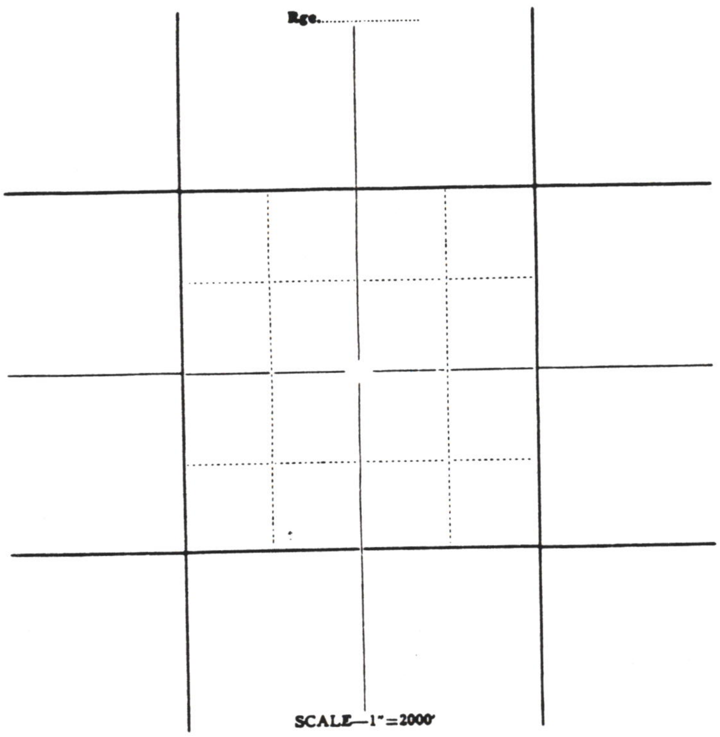
Attachment 1 continued

Locate well by footage measurement from legal subdivision (Section) line and nearest drilling or producible well, if any.

Form No. 2
File at
Billings
or Shelby

Locate
Well
Correctly

Twp. ....



Form No. 2
File at
Billings
or Shelby

THE NOTICE OF INTENTION TO DRILL THIS WELL IS APPROVED SUBJECT TO THE FOLLOWING CONDITIONS:

1. Any person, before commencing the drilling of any oil or gas well or water source or injection well shall secure from the Board a drilling permit and shall pay to the Board the following amounts: for each well whose estimated depth is thirty-five hundred (3,500) feet or less, twenty-five dollars ($25.00); from thirty-five hundred and one (3,501) feet to seven thousand (7,000) feet, seventy-five dollars ($75.00); seven thousand and one (7,001) feet and deeper, one hundred fifty dollars ($150.00).

2. No well is to be spudded in unless the proper surety drilling bond has been posted and approved by the Board of Oil and Gas Conservation of the State of Montana. Date of spudding must be reported to the Board verbally or in writing within 72 hours of commencing drilling.

3. Cable tool operators must construct an adequate sump to contain all mud and water bailed from the hole.

4. Surface or conductor casing must be properly cemented by an approved method and pressure tested to determine a tight bond with the surrounding formations in case an unexpected flow of oil, gas or water should be encountered, unless special permission has been granted for formation shut-off.

5. Any production casing must be cemented unless a formation shut-off or packer is approved by the Board. Sufficient cement must be used to protect the casing and all possible productive and fresh water bearing formations exposed in the process of drilling and not otherwise protected.

6. All production casing must be tested by bailing or pressure to determine if there is a tight bond with the surrounding formations or possible leaks in the casing. The results of the test must be reported on Form No. 2, said report to include the size, weight, thread and length of casing, amount of cement used, and date work is done. If test shows failure, the defect must be corrected before any drilling operations are resumed.

7. Any contemplated change in status of a well such as to plug and abandon, deepen, plug back, redrill, alter casing, etc. must be presented on Form No. 2 for approval by the Board prior to commencement of work.

8. A satisfactory drilling record must be kept for each tour, showing top and thickness of each and all formations drilled and all other information of value, one copy of which is to be kept at the rig while drilling is in progress for examination by any authorized agent of the Board.

9. All producing wells must be marked with name of the operator, number of the well and location, using reasonable precautions to preserve these markings at all times.

10. Delivery to the Board of two copies of all surveys, reports, analyses, logs, tests, samples and core descriptions, etc., as described in Rule 36.22.1013 and one copy of all cementing records as furnished by the cementing company and described in Rule 36.22.1241.

11. All work must be done in conformity with the regulations of the Board of Oil and Gas Conservation of the State of Montana, as contained in "General Rules and Regulations," and amendments thereto, as well as regulations prescribed in lieu thereof.